OCTOBER 2003

Decommissioning the Reactor
Reactor Internals Removal & Vessel Segmentation

NASA Glenn
Plum Brook Station

This is one in a series of fact sheets prepared by NASA Glenn Research Center to provide the public with information on decommissioning the closed Reactor Facility at Plum Brook Station.

This fact sheet describes NASA's careful planning and approach to systematically taking apart the reactor vessel, known as segmentation. Segmentation minimizes the volume of the reactor vessel for safe packaging, transport and disposal.

In preparation for decommissioning the Reactor Facility, NASA conducted comprehensive radiological surveys that revealed roughly sixty percent of the remaining radioactivity - and the most significant source of radiation at the site - existed in components attached inside the reactor and in the vessel walls. NASA recognized early in decommissioning planning that the relatively small size and physical makeup of the Reactor Facility's 60-megawatt reactor vessel lends itself to being disassembled rather than being shipped in one piece for disposal. Further investigations indicated that the remaining radioactivity was concentrated in specific components located nearest to the reactor core - in three horizontal beam tubes and two beryllium plates (described below).

All nuclear fuel was removed in 1973 when NASA closed the Reactor Facility.

NASA determined that removing these components first, followed by dismantling or segmenting the vessel walls would greatly reduce the on-site radiation source from the start. This approach would minimize the potential for workers being exposed to elevated radiation levels during the rest of decommissioning. It also required intricate planning to ensure the safety of workers performing the internals removal and vessel segmentation.

Segmentation Plan

The first step NASA and its Decommissioning Team contractor Wachs Technical Services, Inc. took in segmentation planning, was to define the materials present in the reactor and their radioactivity. Next Wachs identified the necessary "size-reducing" technologies - conventional methods such as unbolting, cutting and milling - and designed tools uniquely modified for this segmentation work. A segmentation plan was developed that sequenced the work with exacting detail - specifying the tools and techniques to be used. The plan also recorded each item's expected shape, weight, radioactivity level, its proper disposal liner, shipping container, and ultimate destination for disposal. Each segmentation activity was laid out in advance and all team members understood how the work would be accomplished. The current segmentation plan consists of seven phases (see text on right).

ALARA Analysis

Dose estimates were calculated based on the time it would take to complete each task. The ALARA analysis (keeping radiation dose As Low As Reasonably Achievable) for segmentation indicated that certain changes were needed in NASA's original plan to minimize the potential radiation dose to segmentation workers. The ALARA analysis, backed by information gained from two reactor vessel entry investigations and interviews with NASA retirees (the last to see the reactor in operation) specified the engineering controls and personal protective equipment necessary for keeping workers safe (see text on back side bar).

Support Systems in Place

As part of segmentation planning, several important preparations were made.

- Loose and fixed pieces of equipment from the Reactor Facility's four quadrants (A-D) and canals were removed and safely shipped to the Alaron waste processing facility in Wampum, Pennsylvania.
- Cranes were load-tested and crane operators were certified.
- The old electrical system was disabled; new temporary power and safety lighting were installed.
- The Cask Transfer System, a trolley-like track and structural supports, was installed to transfer waste liners to casks and transport vehicles.
- A ventilation system was installed to provide clean air to workers inside the containment vessel and filter the air before it is exhausted to the outside.
- Waste facility contracts were finalized and all necessary permits were obtained.

Workers remove fixed equipment from quadrants and canals.

The segmentation plan is divided into distinct phases of operation.

PHASE 0
Equipment set up & testing

PHASE 1
Remove horizontal beam tubes

PHASE 1A
Remove internals above the reactor core

PHASE 2
Remove internals at the core

PHASE 3
Remove internals below the core

PHASE 4
Remove reactor vessel

PHASE 5
Clean up & demobilization

SAFETY FOR WORKERS

With safety for workers as the primary goal, NASA adheres to the ALARA principles (radiation exposure that is As Low As Reasonably Achievable). Throughout decommissioning, NASA monitors each worker while in a potentially radioactive environment, checking for accumulated dose, if any. NASA conducted an ALARA analysis and other safety reviews as part of segmentation planning.

The final plan for segmentation is based on the three important principles of radiation safety - Time, Distance and Shielding - as ways to keep worker exposure levels as low as reasonably achievable.

Time

Dose estimates were calculated based on the time it would take to complete each task. Dose was minimized by limiting both the number of people in the radioactive environment and the time they spent there (due to improving proficiency with tool and techniques beforehand).

Distance

The segmentation plan called for work to be performed remotely using modified tools equipped with long, articulated handles (bent to reach around shielding, keeping workers out of the radiation field).

Shielding

►The three metal shrapnel shields at the reactor opening were modified and put back in place to provide additional shielding to workers above on the work platform. An eight-foot hole was cut in the shields for putting tools down into the reactor and pulling pieces out.

►Portable steel and lead "shadow shields" protect crane operators and others while pieces with a significant radiation field are being transferred to a waste liner.

►A "dedicated cask" houses the waste liner as it is being filled on the Cask Transfer System. The thick metal cask provides additional shielding from the liner contents to workers inside the containment vessel.

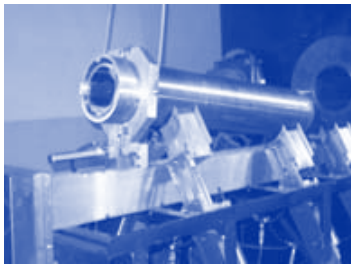
Equipment Set-up and Testing (Phase 0)

As segmentation tools were made in the Wach's North Carolina facility, workers tested them on actual mock-ups (built-to-size duplicate reactor components). Lessons learned from these exercises were used to improve the tools for efficiency and precision. Mock-ups were later transferred to the Reactor Facility where workers practiced and perfected segmentation methods.

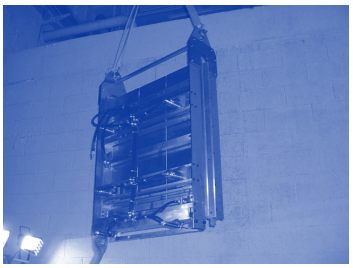
NASA used the Reactor Facility's own 100-kilowatt Mock-Up Reactor for practice experiments over thirty years ago, and again more recently for training exercises leading to segmentation. Workers practiced segmentation techniques on the Mock-Up Reactor - a near duplicate to the main reactor but having a very low-level radioactive environment. These rehearsals enabled workers to become proficient with the tools while identifying and correcting procedural problems before actual segmentation. This approach had the added benefit of dismantling a majority of the Mock-Up Reactor in the process.

With the Reactor Facility's quadrants and canals cleared of loose and fixed equipment, all support systems ready and all special tools and supplies in place, NASA began decommissioning the reactor this summer - starting with removal of the horizontal beam tubes and continuing with the beryllium plates.

Reactor Internals Removal



NASA first removed the three horizontal beam tubes.



The beryllium plates are being clamped to prevent cracking.

Horizontal Beam Tubes (Phase 1)

When the Reactor Facility was in operation, experiments were placed next to the reactor core through three horizontal beam tubes (HB tubes) - metal pipes roughly 14 inches in diameter and 7 feet long that ran through the vessel wall up to the core box.

Workers operated equipment remotely while watching video monitors showing the work area from various angles. A specially designed table device withdrew a section of the HB tube from the side of the reactor into quadrant D where it was cut using a custom-made bandsaw blade. A crane lifted the piece out of quadrant and into a shielded liner (see description below). The process was repeated - removing three HB tubes (1-3).

Beryllium Plates (Phases 2)

Two beryllium plates - having been used to reflect neutrons at the reactor core during operations - had become activated. Several precautions are being taken to prevent breaks in the plates that will eliminate the release of tritium - radioactive gas that is formed when beryllium is exposed to air. Workers are using articulated tooling to lower a special handling fixture into the reactor to clamp and secure the plates. A crane will lift the plates out of the reactor and into a steel box. A polyurethane substance will be injected into the box surrounding and immobilizing the beryllium. The box will be placed into a liner, and again filled with the polyurethane.

As HB tubes and boxed beryllium plates are removed, they are placed by crane directly into waste liners that are housed in a "dedicated cask" on the Cask Transfer System (see side bar Shielding). The liner and cask are transferred out of the containment vessel. A crane lifts the liner to the actual shipping cask for transport to the Barnwell Disposal Facility in South Carolina where the liner and its contents will be buried.

Reactor Vessel Segmentation

After all reactor internals have been removed at and below the reactor core box during Phase 3, segmentation of the vessel walls can begin in Phase 4. Facility records show that when the vessel was built, the concrete walls were covered with a layer of asbestos. The first step to segmenting the vessel will involve boring into the walls to take and analyze samples for asbestos content. Asbestos abatement will be conducted where necessary. Next, workers will methodically cut away eighty-nine pipes that penetrate the vessel walls. Finally, they will dismantle the walls by unbolting, milling and cutting them to pieces according to the specifications that have been fully described in the segmentation plan.

When reactor internals removal and vessel segmentation are complete (expected near the end of 2004), NASA will have significantly reduced the amount of on-site radioactivity and will have accomplished a major decommissioning milestone.

For more information on Decommissioning the Reactor Facility at Plum Brook Station, Contact **Sally Harrington** at **216-433-2037** or Email **s.harrington@grc.nasa.gov**. or visit us at our Website at **www.grc.nasa.gov/www/pbrf** or call our toll-free number at **1-800-260-3838** for regularly updated progress reports.

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